ES202 Lab 7 - Groundwater Processes, Resources, and Risks

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Part 1. Station 1 Static Groundwater Model

At Station 1, examine the physical model of a simple groundwater aquifer system. The basic components of the model include three wells (Well A, B, and C), and a sequence of unconsolidated, layered sediments (Units 1, 2, and 3). Answer the following questions.

1. Make some basic stratigraphic observations regarding the physical sedimentology of Units 1, 2, and 3. Refer to your sedimentology notes as needed. Fill in the table below.

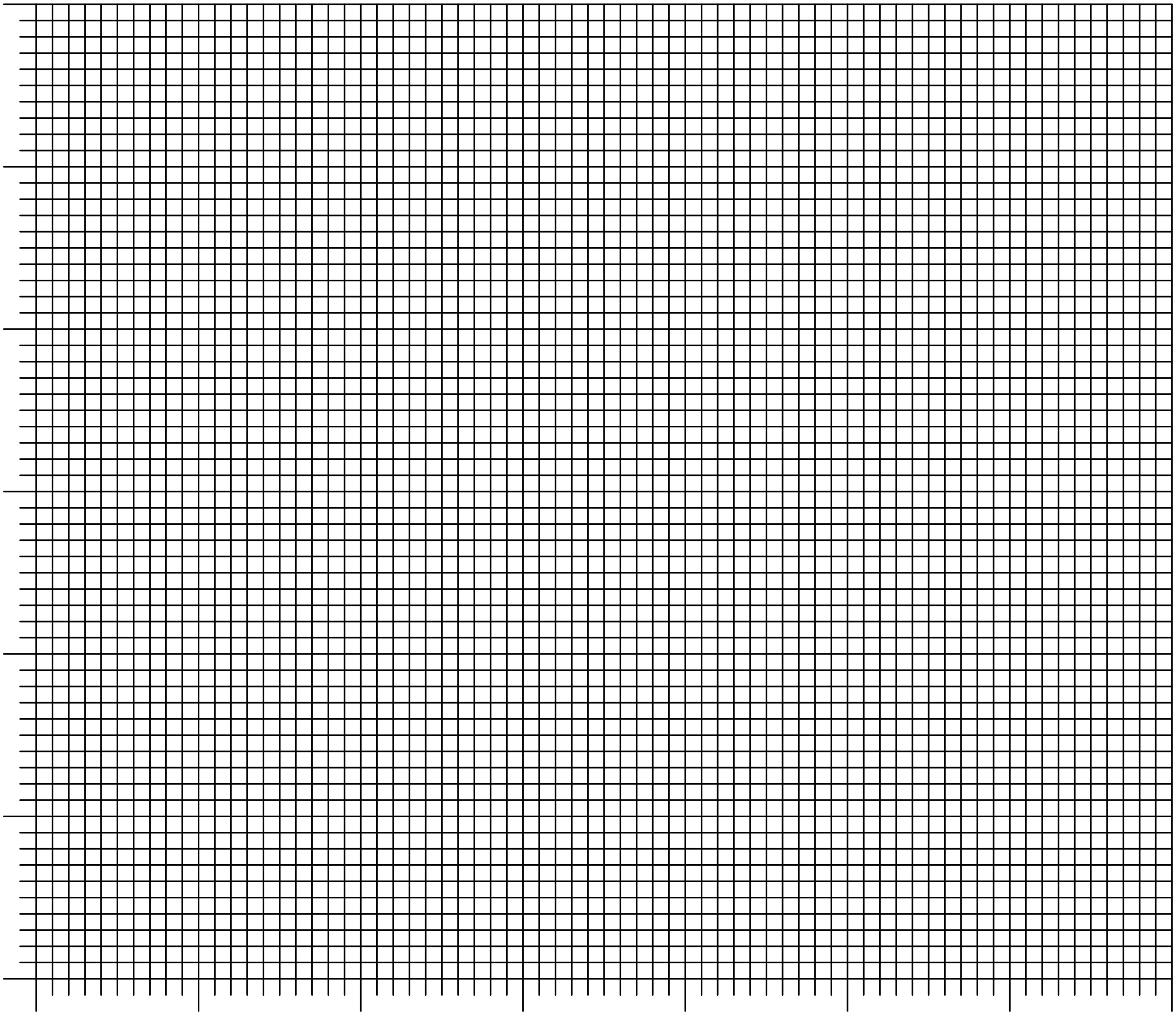
Unit No.	Bed Thickness (cm)	Grain Size (mm)	Sediment Name	Sorting
1	____________	___________	_____________	_____
2	____________	___________	_____________	_____
3	____________	___________	_____________	_____

2. On the graph provided on the next page, draw a cross-section to scale, showing the basic configuration of the layered sediments. Use a fractional scale of 1:2 (1 unit on the cross-section = 2 units on the groundwater model). Use a ruler to measure the thickness of the sediment beds to the nearest millimeter. Include in your cross-section a diagrammatic illustration of grain size for each unit, label all parts of your cross-section appropriately.

3. Pour a small volume of water (about 5 ml) onto the surface of Unit 3. Describe your observations of Unit 3 in terms of texture, porosity, and permeability.

   Is Unit 3 presently saturated with respect to groundwater? Explain your observations and answer.

   How about Units 1 and 2? Explain as above; draw diagrams as necessary.



Cross-sectional profile of groundwater model. Scale the model 1:2 (1 unit on model = 2 units on graph)

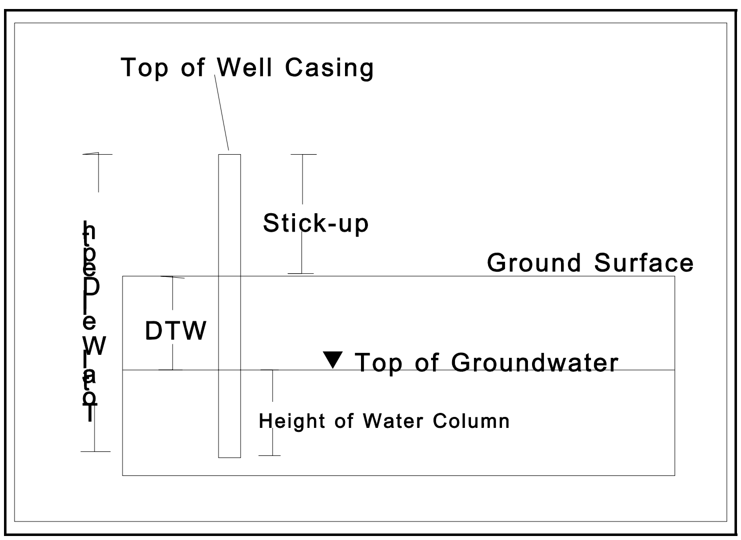
4. Based on grain size and sorting characteristics, identify the relative porosity and permeability of the three stratigraphic units comprising the model. Use descriptive terms such as highly porous/permeable, moderately porous/permeable, low porosity/permeability. Fill in the table below.

Unit	Porosity	Permeability
1	______________	______________
2	______________	______________
3	______________	______________

5. Based on your observations from the physical model, which of the following tend to make good aquifers and aquitards. Your choices for answers include "good" or "poor".

	Aquifer?	Aquitard?
Poorly Sorted Clayey Sand	______________	______________
Clay	______________	______________
Well-Sorted Gravel	______________	______________
Well-Sorted Sand	______________	______________
Shale	______________	______________
Fractured Limestone	______________	______________

6. Perform the following measurements on the groundwater model, fill in the data table.
   - A) Measure the stick-up (above ground surface) of the well casings (the distance from the ground surface to the top of the well). Measure in centimeters to the nearest decimal place.
   - B) Use the "dip stick" to measure the depth to the top of water in each well.
   - C) Determine the depth to water below "ground surface" (total depth to water minus well stick up). Measure in centimeters to the nearest decimal place.
   - D) Measure the total depth to the bottom of the well. Measure in centimeters to the nearest decimal place.
   - E) Calculate the height of the column of water in each well (in centimeters, to the nearest decimal).



Well I.D.	Well Casing Stick-up (cm)	Depth to Water from top of well (cm)	DTW below ground surface (cm)	Total Well Depth (cm)	Height of Water Column (cm)
A	_________	_________	_________	_________	_________
B	_________	_________	_________	_________	_________
C	_________	_________	_________	_________	_________

7. Are any of the wells "dry" with no ground water? Which ones?

   Which stratigraphic unit is associated with the dry well (hint: compare your well depth to the depth of strata in the model).

   By looking at the model, what would be the minimum depth that you would have to drill to find an abundant supply of ground water (answer in cm below ground surface). Which stratigraphic unit is the best aquifer in this case?

8. By looking at the model, do you see any visible flow of the ground water through the system? (is the ground water flowing "like an underground river").

9. Let's create an imaginary frame of reference with respect to elevation. Let's assume that the ground surface of the model lies at an elevation datum of +500 cm above relative sea level. From your table of data above, determine the elevation of the top of the ground water surface at each of the wells. Fill in the table below.

Well I.D.	Depth to water from ground surface (cm)	Elevation of ground surfaceof (cm)	Elevation of top well casing (cm)	Elevation of top of water (cm)
A	_______	_______	_______	_______
B	_______	_______	_______	_______
C	_______	_______	_______	_______

10. Compare your calculations in question 9 to your observations in question 8, what can you conclude about changes in elevation of the ground water surface and ground water flow velocity? Write a conceptual equation that relates water surface elevation change to ground water flow velocity.

Station 2 Activities.

Visit Station 2 and examine the display. There are four types of porosity that can be found in rock and sediments. These include (1) intergranular porosity (open pore spaces between grains, primarily the result of deposition), (2) solution porosity (open pore spaces result from chemical dissolution of salt and limestone deposits by ground water), (3) fracture porosity (open pore spaces result from fracturing of rocks by tectonic forces, the fractures form opening through which fluids can migrate), and (4) vesicular porosity (open pore spaces associated with vesicular volcanic rocks). Fractures are typically arranged in geometric patterns (rectangular shapes, etc.), depending on the orientation of tectonic forces at the time of fracture.

There are five earth materials samples at Station 2 with examples of different types and degrees of porosity and permeability. Use the water bottle and make observations for each sample with regards to its ability to store and transmit water. Use terms like Low, Medium, High for degree of porosity and permeability. For porosity type, your choices include intergranular, fracture, solution, and vesicular. Fill in the data table below.

Sample I.D.	Degree of Porosity	Degree of Permeability	Porosity Type
A	________________	________________	________________
B	________________	________________	________________
C	________________	________________	________________
D	________________	________________	________________
E	________________	________________	________________
F	________________	________________	________________

Station 3 – Models and Air Photos

Station 3 A (new photo atlas stereopair – p. 3 western OK)

Describe the drainage pattern evident in the air photo. Does the underlying bedrock likely consist of limestone? Why or why not, explain your answer.

Station 3 B (new photo atlas stereopair – p. 40 Myakka River SP Fla)

Compare the air photos to the 3D plastic model at the station. Identify topographic features labeled A and B. How do they form? What bedrock type likely underlies this part of Florida? Is the drainage pattern dendritic, rectangular, radial, trellis, or none of the above? Explain your answer

Station 3C (old photo atlas, p. 5, Puerto Rico)

The topography displayed in this photo pair is termed “tower karst”, describe the landscape elements that comprise tower karst including the configuration of the hills and the nature of the drainage pattern. What type of bedrock underlies this region?

Station 4: Groundwater Simulation Model

Visit the groundwater simulation model and answer the following questions.

4-1. Identify the earth materials comprising the following units, include a description of relative porosity, relative permeability, and whether the material is acting as an aquifer or aquitard.

	Material Type	Relative Porosity (High, Medium, Low)	Relative Permeability (High, Medium Low)	Aquifer or Aquitard?
Unit 1	_______	__________	________	_____________
Unit 2	_______	__________	________	_____________
Unit 3	_______	__________	________	_____________
Unit 4	_______	__________	________	_____________

4-2. Examine units 3A and 3B. Describe their composition, their potential as aquifers, and their lateral continuity with respect to other portions of unit 3 (i.e. are they laterally continuous or discontinuous?). Describe a depositional process that might result in the lateral geometry of units 3A and 3B illustrated in the model.

4-3. Is unit 1 acting as a confined or unconfined aquifer? Explain your answer.

4-4. Is unit 3 acting as a confined or unconfined aquifer? Explain your answer.

4-5. Is unit 4 in direct hydraulic communication with unit 3? (i.e. are the units readily exchanging fluids?) Explain your answer.

4-6. Is unit 4 in direct hydraulic communication with unit 1? Explain your answer.

4-7. If gasoline leaked from the storage tank, would it contaminate unit 1? Why or why not?

4-8. Examine the set of wells on the groundwater simulation model. Note that the top of the wells are all located at the same elevation. Assume the the groundwater model has a scale of 1:500 (i.e. 1 inch depth on the model = 500 inches depth relative to the Earth), and that the elevation of the top of the wells is 1500 ft above sea level (relative to the actual Earth's surface). Using a ruler and the scale, fill in the well data chart below.

Well ID	Depth to water (model inches)	Depth to Water (actual ground feet)	Elevation of Water Surface (ft elev.)	Is well in confined or unconfined aquifer?
A	____________	__________	___________	______________
B	____________	__________	___________	______________
C	____________	__________	___________	______________
D	____________	__________	___________	______________
E	____________	__________	___________	______________
F	____________	__________	___________	______________
G	____________	__________	___________	______________
H	____________	__________	___________	______________
I	____________	__________	___________	______________
J	____________	__________	___________	______________
K	____________	__________	___________	______________

4-9. True or False: groundwater flows from high elevation to low elevation, under the influence of gravity?

4-10. What is the elevation of water in the unconfined aquifer in well A? What is the elevation of water table in the unconfined aquifer in Well J? Using the model scale of 1:500, determine the actual ground-distance of the gradient of the water table between well A and well J (remember from the river lab: gradient = change in elevation / change in horizontal distance or rise / run). Calculate the gradient in ft/mi, show all of your work.

4-11. Which direction is groundwater flowing in the unconfined aquifer? Which direction is groundwater flowing in the confined aquifer?

4-12. Is well B in the confined or unconfined aquifer? Is well C in the confined or unconfined aquifer? How does the water level in well B compare that that in well C (answer in model elevation units)? Is the water level in well B above or below the top of the aquifer? Is the water level in well C above or below the top of the aquifer? Are the water levels in wells B and C measuring the same hydraulic pressure? Explain your answer.

4-13. Which aquifer is contributing water to Lake Bonneville? Which aquifer is contributing water to Smith Lake?

Part 2. Lab Manual Exercises

Using your lab manual, complete the following exercises in "Laboratory 12 – Groundwater". Draw on maps from your lab manual as requested. Answer on separate sheets as needed. Three-hole punch and include all materials in your lab portfolios.

Activity 12.1 (p. 285) Karst Topography

Questions A.1., A.2., A.3. (p. 285)

Here are some additional notes to help you think about this one...Visit Station 2 and examine the display to help you think about this question. Hint: linear features are related to rock cracks, think about how they influence porosity and permeability. Which type of porosity is controlling the linear arrangement of plant growth (plants like water, water follows porosity/openings, plants grow along openings)

Additional questions: examine Fig. 12.5, this is a view of the roof of a cavern. Are these mineral deposits stalactites or stalagmites? What is the precise chemical formula for these deposits? How is Fig. 12.5 related to 12.4? (hint: note the geometric arrangement of the cave deposits).

Questions B.1., B.2., B.3. (p. 285)

Note: limestone caves form from the dissolution of calcite by carbonic acid in rainfall and percolating groundwater.

Question C.1., and C.2. (p. 285)

Questions D.1. through D.5. inclusive (p. 285). Here are some hints:

Use the difference in vegetation and topography to design your answer, look for differences in topographic texture, compare dendritic "normal" drainage patterns to the swiss-cheese, irregular patterns.

Activity 12.2 (p. 287) Florida Aquifer

Question A (p. 287) – read the blue numbers on the lakes, they are lake water elevations, mark them on the base map of lakes provided on map p. 288

Question B (p. 287)

Extra information: refer to Fig. 9.10 on p. 209 for the basic approach to drawing contour lines. The idea here is that the sink hole lakes are "windows" through the rock into the water table. Hence the elevation of the lake surface is equal to the elevations of the water table. The idea is to draw lines of equal elevation through the lake levels. Try to approximate lines that connect points of equal elevation on the water table, with lines drawn on elevations that are multiples of 5.

Questions C., D, E., F, G. H.

note: velocity = (distance / time); find the distance between Blue Sinks and Sulphur Springs and divide by the travel time to determine groundwater flow velocity. Hint: increased building + people = increased water use. Hint: think of water resource problems and sink hole development.

Activity 12.3 Groundwater Withdrawal and Land Subsidence (p. 289)

Questions A1-2 and B1-10, inclusive (i.e. do all of numbered parts) (p. 289-290).

Hint: Question A1. and A2, identify and shade all areas where the groundwater elevation is higher than land elevation. This indicates areas that are associated with artesian groundwater conditions, i.e. groundwater is under pressure and will rise above the ground surface.